MODELING ANTENNA PERFORMANCE WITH AN EFFICIENT HYBRID FINITE ELEMENT - INTEGRAL EQUATION - WAVEGUIDE MODE MATCHING TECHNIQUE

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ABSTRACT

An efficient hybrid finite element - integral equation technique has recently being devc.loped to model EM scattering from three - dimensional inhomogeneous penetrable bodies of arbitrary shape, and is currently being extended to treat radiation problems. The salient features of the method arc presented here and results are illustrated for some simple antennas, and contrasted with measured data.

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SUMMARY

The finite element technique is very appealing for its ability to accurately model the physical features of an object to a scale much smaller than the wave.length of interest, particularly when one is concerned with the evaluation of near - zone fields or field related quantities inside a penetrable object, as is the case in ante.nna design and analysis.

To limit the computational domain in the case of open structures, an integral equation is set - up on a mathematical surface of revolution enveloping the true scatterer/radiator, thus enforcing an exact boundary condition. The surface of revolution needs not be in the far - field, thus reducing the problem size compared to alternative truncation methods employing absorbing boundary conditions. Moreover, the choice of a surface, of revolution allows for a very efficient representation of the surface integral equation unknowns and resulting matrices [1].

To incorporate the treatment of radiation it is necessary to describe the source consistently with the finite element modeling techique. Prescription of the source fields is possible for a variety of simple cases [2], but it is generally difficult for a realistic antenna, where the feed is complicated. We propose here an approach which applies to antennas fed by waveguides or coaxial cable.s, but which are otherwise of general shape and material composition

In many practical cases radiating structures are fed by waveguides/coaxial cables, and an interface can be located which optimally separates the two. Such an interface is employed here as an additional surface which bounds the computational domain, thus allowing us to model only the radiating structure per se. At the interface, and looking toward the source, the representation of the EM fields is conveniently done via a waveguide mode decomposition, accounting for propagating and evanescent modes arising in the presence of geometric discontinuities at or near the interface. On the other hand, looking into the radiating structure, the finite element model completely describes the unknown field. By matching the two representations a constraint on the unknown field is found which allows for the correct truncation of the computational domain, without introducing additional unknowns, once the dominant wave.guide mode is specified.

The formulation of this technique makes use. of an integral form of the wave equation in the volume of computation, written for either the magnetic or the electric field, and of a combined electric field - magnetic field integral equation on the bounding surface. of revolution, written for both electric and magnetic surface currents. A third equation is obtained by explicitly enforcing continuity of the tangential component of the unknown field at the surface of revolution, as expressed by the two representations. In the wave equation, matching of the waveguide modal representation to the finite element rc.presentation at the antenna interface is accomplished via a proper surface integral term, involving only the unknowns representing the tangential field at this surface.

First order, vector edge - elements are used in our finite element representation, and the unknowns are the field components along each edge of the tetrahedral elements meshing the computational domain, On the surface of revolution an additional set of surface currents unknowns is introduced for the integral equation; the surface currents are represented as linearly varying along the generator and having a Fourier series azimuthal variation. Construction and meshing of the radiator, and the volume of air surrounding it up to the bounding surface, is accomplished with the use of a commercially available package.

The problem of the radiation from an open - ended waveguide is presented here as an example, to validate the approach and to illustrate how to efficiently handle unbounded radiators. Preliminary results of $E\rho$ calculated at the waveguide interface are shown in Fig. 1, contrasted with the analytical solution. The issues of optimal mesh choice and related accuracy will be discussed.

[1] "T. Cwik, C. Zuffada and V. Jamnejad: " Coupling Finite Element and Integral Equation Representations to Efficiently Model Three - Dimensional Objects, " submitted for publication on the IEEE Transactions on Antennas and Propagation, August 94.

[2] V. Jamnejad, T. Cwik and C. Zuffada: " Application of the Coupled Finite Element - Combined Field Integral Equation Technique to Electromagnetic Radiation Problems," 1994 IEEE APS/URSI Symposium Proceedings, Seattle, WA, June 1994.

CIRCULAR WAVEGUIDE KA = 2
COMPARISON BETWEEN CALCULATED AND THEORETICAL Eρ